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CERTIFIED TRANSLATION

I, Kenichi AIHARA, am an official translator of the Japanese language into the English Language and I hereby certify that the attached comprises an accurate translation into English of Japanese Patent Application No. 2002-325791, filed on November 8, 2002.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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[Title of the Invention] Flying Head Slider and Disk Storage Apparatus Using the Same

[Claims]

[Claim 1] A flying head slider that is incorporated in a disk storage apparatus and records and reproduces information to and from a disk-shaped storage medium,

wherein a face thereof facing said storage medium comprises three surfaces that are a positive pressure generating surface, a step having a lower height than said positive pressure generating surface, and a recess having a lower height than said step,

wherein said positive pressure generating surface comprises:

a U-shaped leading pad having a projection on an air inflow side thereof, said leading pad being positioned at a front part of said slider;

two side pads that are positioned behind said leading pad and on the right and left sides thereof; and

a center pad having a recess on the air inflow side thereof, said center pad being positioned between said two side pads and behind said leading pad,

wherein said step comprises:

a leading step that extends from a front edge of said leading pad to a front edge of said slider;

two side steps, each extending from right or left rear of said leading pad to any one of said two side pads and connecting the pad; and

a center step having a projection on the air

inflow side thereof and extending forward from a front edge of said center pad,

wherein said recess is formed at the peripheries of said center pad and said center step, which are surrounded by said leading pad, said side steps, and said side pads,

wherein said side steps each extends from a side part of each side pad to a side edge of said slider; a width of said leading pad is formed so that it can be narrower than a total width of said slider; and said leading step and said side steps are joined at side parts of the slider and extend to the side edges of said slider,

wherein each of said side steps is wider at the rear,

wherein a rear edge of said center pad is positioned further behind the rear edges of said side pads, and

wherein a head is positioned near the rear edge of said center pad.

[Claim 2] The flying head slider of Claim 1, wherein said two side pads have projections on their air inflow sides.

[Claim 3] The flying head slider of Claim 1, wherein said two side pads have recesses on their air inflow sides.

[Claim 4] The flying head slider of Claim 1, wherein said positive pressure generating surface has a shape so that it falls to said recess without any step, on a part of contour part excluding a part thereof that can also be on the air inflow side and is connected to said side steps, said contour part being able to become on an air outflow side within a range of skew angles to be used.

[Claim 5] The flying head slider of Claim 4, wherein the contour part of said positive pressure generating surface has a continuous shape comprising only of curved line and tangent of the curved line at parts raised from said step, and has a discontinuous shape at cross points between parts raised from said step and parts raised from said recess, and at cross points between parts raised from said step and a slider edge face.

[Claim 6] The flying head slider of Claim 1, wherein said leading pad has a shape such that said leading pad is thickest at a center part thereof and becomes gradually narrower toward both ends thereof.

[Claim 7] The flying head slider of Claim 1, wherein said positive pressure generating surfaces, said steps and said recesses are symmetrical with respect to a center line of a longitudinal direction of said slider.

[Claim 8] The flying head slider of Claim 1, wherein said leading pad is split into two parts in a width direction of said slider.

[Claim 9] A disk storage apparatus comprising a disk-shaped recording medium and a flying head slider having a head, which records and reproduces information to and from said recording medium,

wherein a face of said flying head slider, which faces said storage medium, comprises three surfaces that are a positive pressure generating surface, a step having a lower height than said positive pressure generating surface, and

a recess having a lower height than said step,

wherein said positive pressure generating surface comprises:

a U-shaped leading pad having a projection on an air inflow side thereof, said leading pad being positioned at a front part of said slider;

two side pads that are positioned behind said leading pad and to the right and left sides thereof; and

a center pad having a recess on the air inflow side thereof, said center pad being positioned between said two side pads and behind said leading pad,

wherein said step comprises:

a leading step that extends from a front edge of said leading pad to a front edge of said slider;

two side steps, each extending from right or left rear of said leading pad to any one of said two side pads and connecting it; and

a center step having a projection on the air inflow side thereof and extending forward from a front edge of said center pad,

wherein said recess is formed at the peripheries of said center pad and said center step, which are surrounded by said leading pad, said side steps, and side pads,

wherein said side steps each extends from a side part of each side pad to a side part of said slider; a width of said leading pad is formed so that it can be narrower than a total width of said slider; and said leading step and said side steps are joined at side parts of said slider and extend to the side edges of said slider,

wherein each of said side steps is wider at the rear,

wherein the rear edge of said center pad is positioned further behind the rear edges of said side pads, and

wherein said head is positioned near the rear edge of said center pad.

[Claim 10] The disk storage apparatus of Claim 9, wherein said storage medium is a fixed type hard disk drive, which is irremovably incorporated.

[Claim 11] The disk storage apparatus of Claim 9, wherein said storage medium is a removable hard disk drive, which is removably stored in a cartridge.

[Detailed Explanation of the Invention]

[0001]

[Technical Art to which the invention belongs]

The present invention relates to a flying head slider for flying a head that reads and writes information from and to a disk-shaped storage medium and a disk storage apparatus in which the flying head slider is used. More specifically, it relates to the head slider including a positive pressure generating surface, which have shapes that would enable a flexible design, while ensuring stiffness in pitch direction and in roll direction and a step, which is lower in height than the positive pressure generating surface, extending to a front side and side edges of the slider on an air inflow side of the positive pressure generating surface, thereby preventing dust particles from entering into a boundary surface between the flying head slider and a disk and ensuring stable fly height characteristics.

[0002]

[Prior Art]

Fig. 10 are explanatory diagrams each showing an example of a configuration of a flying head slider of a prior art, which is incorporated into a hard disk drive, in which Fig. 10A is a perspective view thereof and Fig. 10B is a plane view thereof. Furthermore, Fig. 11 is a plane diagram showing an example of a configuration of a hard disk drive of the prior art. In order to describe an internal configuration of the hard disk drive in Fig. 11, a cover, which is not shown in the figure, has been removed.

[0003]

A flying head slider 51 includes a positive pressure generating surface 53; a step 54, which is a shallow groove that is lower in height than that of the positive pressure generating surface 53; and a recess 55, which is a deep groove that is lower in height than that of the step 54; all of which are formed on an opposite face that faces a disk 52 shown in Fig. 11.

[0004]

The hard disk drive 56 includes a head actuator 59 that has a suspension 57, which supports the flying head slider 51 on a tip side thereof, and an arm main body 58, on which the suspension 57 is secured.

[0005]

The head actuator 59 is fitted so that the arm main body 58 can rotate around a pivot 60 as an axis. Furthermore, the head actuator 59 is rotationally driven by a voice coil motor 61, which is placed on an opposite side of the suspension 57 across the pivot 60.

[0006]

The flying head slider 51 has a configuration such that

when the disk 52 is rotated by a spindle motor, which is not shown, a positive pressure for lifting force away from the disk 52 as a result of an air flow that accompanies the rotation of the disk 52 can be generated at the positive pressure generating surface 53 and a negative pressure for pulling toward the disk 52 can be also generated at a negative pressure generating area 62, which is a shaded area in the recess 55, thereby allowing a stable fly height to be achieved by a balance of forces among a load of the suspension 57, which presses the flying head slider 51 toward the disk 52, the positive pressure, and the negative pressure.

[0007]

Furthermore, the voice coil motor 61 rotates the head actuator 59 and moves the flying head slider 51 between an inner circumference side and an outer circumference side of the disk 52 in order to record or reproduce information.

[0008]

In the mean time, the hard disk drive 56 allows the head actuator 59 to rotate and the flying head slider 51 to move between the inner circumference side and the outer circumference side of the disk 52, while the disk 52 is maintained at a constant revolution speed. For this reason, a speed of the airflow varies in relation to the flying head slider 51 depending on whether the flying head slider 51 is at the inner circumference side of the disk 52 or at the outer circumference side of the disk 52. Furthermore, because the flying head slider 51 moves as a result of rotational operation of the head actuator 59, an angle of the flying head slider 51, which is called a skew angle, in relation to the airflow also varies depending on whether the flying head slider 51 is at the inner circumference side of the disk 52

or at the outer circumference side.

[0009]

Therefore, a shape of, for example, the positive pressure generating surface of the flying head slider of the prior art is designed to achieve a constant flying height (CFH) characteristics and to improve skew dependence characteristics and linear speed dependence characteristics.

[0010]

In other words, instead of a positive pressure generating surface 52 etc., which have a straight shape on the air inflow side, as shown on the flying head slider 51 in Fig. 10, a flying head slider may have a projection on the air inflow side of the positive pressure generating surface etc. (For example, see the Patent Document 1.)

[0011]

[Patent Document 1]

Japanese Patent Application Publication No. 2001-60373

[0012]

[Problems to be solved by the Invention]

In recent years, low-flying of the flying head slider has been promoted in order to increase recording density on a disk storage apparatus, such as a hard disk drive, utilizing magnetism. However, there is an issue that, due to the low-flying of the flying head slider, as thickness of an air film between the positive pressure generating surface and the disk is reduced, the drive becomes more susceptible to effects of small dust particles inside the drive.

[0013]

More specifically, there is an issue that when the dust particles enter a boundary surface between the flying head slider and the disk, the flying head slider comes into contact

with the disk surface through the dust particles, so that a suspension would begin to oscillate at its proper mode with it receiving an excitation force, thereby causing a difficulty in following a track. Further, there also is an issue that an excessive amount of dust particles can cause damages on the disk and cause a head crash.

[0014]

Although, in order to address such the issues, for example, it is necessary that the shape of the positive pressure generating surface can be such as to inhibit the dust particles from entering, but there is also an issue that this can impose restrictions on design flexibility and it is often difficult to ensure protection against dust particles and improve CFH characteristics, skew dependence characteristics, and linear speed dependence characteristics, both at the same time.

[0015]

The present invention addresses these issues and has an object to provide a flying head slider, that would not be susceptible to the effects of dust particles but achieves a stable fly height, and a disk storage apparatus in which the flying head slider is used.

[0016]

[Means for solving the Problem]

To address the issues described above, the flying head slider of the present invention is a flying head slider that is incorporated in a disk storage apparatus and records and reproduces information to and from a disk-shaped storage medium, wherein a face thereof facing the storage medium comprises three surfaces that are a positive pressure generating surface, a step having a lower height than the

positive pressure generating surface, and a recess that has a lower height than the step, wherein the positive pressure generating surface comprises a U-shaped leading pad having a projection on an air inflow side thereof, the leading pad being positioned at a front part of the slider, two side pads that are positioned behind the leading pad and on the right and left sides thereof, and a center pad having a recess on the air inflow side thereof, the center pad being positioned between the two side pads and behind the leading pad, wherein the step comprises a leading step that extends from a front edge of the leading pad to a front edge of the slider, two side steps, each extending from right or left rear of the leading pad to any one of the two side pads and connecting the pad, and a center step having a projection on the air inflow side thereof and extending forward from a front edge of the center pad, wherein the recess is formed at the peripheries of the center pad and the center step, which are surrounded by the leading pad, the side steps, and the side pads, wherein the side steps each extends from a side edge of each side pad to a side part of the slider, a width of the leading pad is formed so that it can be narrower than a total width of the slider, and the leading step and the side steps are joined at side parts of the slider and extend to the side edges of the slider, wherein each of the side steps is wider at the rear, wherein the rear edge of the center pad is positioned further behind the rear edges of the side pads, and wherein a head is positioned near the rear edge of the center pad. Furthermore, the disk storage apparatus of the present invention incorporates the flying head slider described above.

[0017]

According to the flying head slider and the disk storage apparatus of the present invention, airflow that is generated as the recording medium rotates generates a lifting force at the front generating surface away from the recording medium.

[0018]

Because the U-shaped leading pad with a projection on the air inflow side thereof is located at the front part of the slider as this positive pressure generating surface, this leading pad can ensure stiffness in pitch direction mainly. Furthermore, because the two side pads are positioned behind the leading pad and on the right and left sides thereof, these side pads can ensure stiffness in roll direction mainly.

[0019]

Furthermore, because a center pad having a recess on the air inflow side thereof is located behind the leading pad and between the two side pads, the shape of the center pad enables control over the fly height characteristics and keeps a freedom in design.

[0020]

Furthermore, because the step, which is at a lower height than the positive pressure generating surface, extends up to the front edge and side edges of the slider at parts corresponding to the air inflow side of the positive pressure generating surface, the dust particles are less likely to penetrate into a boundary surface between the flying head slider and the disk. Furthermore, even in a rare instance in which the dust particles do enter, the dust particles are inhibited from entering into the positive pressure generating surface, which are most susceptible to the effects of dust particles because the dust particles flow along a contour of the positive pressure generating surface, which has a

projection on the air inflow side thereof.

[0021]

[Embodiments of the Invention]

The following will describe embodiments of a flying head slider and a disk storage apparatus of the present invention by referring to the drawings. Fig. 1 are explanatory diagrams each showing an example of a configuration of a flying head slider as a first embodiment thereof; Fig. 1A is a perspective view thereof and Fig. 1B is a plane view thereof. The flying head slider 1 of the first embodiment includes a positive pressure generating surface 2, which is shaped to improve the constant fly height characteristics while providing a freedom in design; and step portion 3 having a lower height than the positive pressure generating surface 2, which is provided at parts that could form an air inflow side thereof, so that the step portion 3 extends up to a front edge and side edges of the slider, thereby preventing dust particles from entering a boundary surface between the flying head slider and a disk.

[0022]

The flying head slider 1 shown in Fig. 1 is incorporated in a hard disk drive, which is an example of a disk storage apparatus, so that a configuration of the hard disk drive will be described first. Fig. 2 is a perspective diagram that shows an example of the configuration of the hard disk drive of the first embodiment. In order to illustrate an internal configuration of a hard disk drive 21 in Fig. 2, a cover, which is not shown in the figure, has been removed.

[0023]

The hard disk drive 21 of the first embodiment is called as a fixed type one from which a disk 22 that is a storage

medium cannot be removed. The flying head slider 1 includes a magnetic head, which is not shown in the figure, for recording and reproducing information to and from the disk 22 and is lifted by airflow that is generated as the disk 22 rotates, to serve as lifting the magnetic head by a prescribed fly height above the disk 22.

[0024]

The hard disk drive 21 has a head actuator 25 including a suspension 23 that supports the flying head slider 1 at a tip thereof and an arm main body 24 on which the suspension 23 is fixed.

[0025]

The head actuator 25 is fitted on a casing 27 so that the arm main body 24 can rotate around a pivot 26. Furthermore, the head actuator 25 is rotationally driven by a voice coil motor 28, which is placed on an opposite side from the suspension 23 across the pivot 26.

[0026]

Furthermore, power is supplied to the head actuator 25 and signals are exchanged with a magnetic head, which is not shown in the figure, by a flexible printed circuit board 29, which is fixed onto the arm main body 24.

[0027]

Furthermore, information is recorded and reproduced by rotating the head actuator 25 with the voice coil motor 28 and moving the flying head slider 1 between an inner circumference side and an outer circumference side of the disk 22 with the disk 22 being rotated by a spindle motor, which is not shown in the figure.

[0028]

The following will describe the flying head slider 1

next in detail by referring back to Fig. 1. Firstly, a size of the flying head slider 1 is illustrated as LxWxH=1.25 mm x 1.0 mm x 0.3 mm, which is called as 30% slider or a Pico slider. In Fig. 1(b), a side indicated by an arrow "a" is an air inflow side or a leading side, while a side indicated by an arrow "b" is air outflow side or a trailing side.

[0029]

An air bearing surface 1a of the flying head slider 1, which faces the disk 22 shown in Fig. 2, includes three layers that are positive pressure generating surfaces 2, a step 3 that is a shallow groove having a lower height than the positive pressure generating surfaces 2, and a recess 4 that is a deep groove having a lower height than the step 3.

[0030]

The positive pressure generating surface 2 includes a leading pad 2a, side pads 2b, 2c, and a center pad 2d. The leading pad 2a is positioned at a front part of the flying head slider 1, is U-shaped one having a projection on the air inflow side, has a width that spans almost entirely across a width of the flying head slider 1, is thickest at a center in the width direction, and becomes gradually narrower at both ends.

[0031]

The two side pads 2b, 2c are placed behind the leading pad 2a and on the left and right sides of the flying head slider 1 and each has a projection on the air inflow side thereof. The center pad 2d is positioned behind the leading pad 2a and at the rear center of the flying head slider 1 and has a recess on the air inflow side thereof.

[0032]

The step 3 has 0.15 um in depth from the positive

pressure generating surfaces 2 and includes a leading step 3a, side steps 3b, 3c, and a center step 3d.

[0033]

The leading step 3a extends from a front edge of the leading pad 2a to a front edge of the flying head slider 1. The two side steps 3b, 3c respectively extend from two side faces of the leading pad 2a to the two side pads 2b, 2c and are connected to the two side pads 2b, 2c. The center step 3d extends frontward from a front edge of the center pad 2d and has a projection on the air inflow side. However, the center step 3d and the leading pad 3a are not connected.

[0034]

The recess 4 has 1.3 um in depth from the positive pressure generating surface 2 and is formed at peripheries of the center pad 2d and the center step 3d, which are surrounded by the leading pad 2a, the side steps 3b, 3c, and the side pads 2b, 2c. Furthermore, a part of the recess 4, which is shaded and is surrounded by the leading pad 2a, is a negative pressure generating area 5.

[0035]

Furthermore, a head 6 for recording and reproducing signals is positioned at a rear end of the center pad 2d. Fig. 3 is an explanatory diagram showing an example of an operation of the flying head slider. The flying head slider 1 is supported by a ball pivot 23a and a supporting member 23b having a spring property, on the suspension 23 so that it is able to swing.

[0036]

The flying head slider 1 has such a configuration that as the disk 22 rotates, a positive pressure is generated at the leading pad 2a, the side pads 2b, 2c, and the center pad

2d, which are shown in Fig. 1, by airflow that results from the rotation of the disk 22 and generates a lifting force away from the disk 22, so that a negative pressure that generates a pulling force towards the disk 22 can be also generated at the negative pressure generating area 5 in the recess 4, thereby enabling the flying head slider 1 to be stably lifted at a point of balance among a load of the suspension 23, which pushes the flying head slider 1 toward the disk 22, the positive pressure, and the negative pressure.

[0037]

When the flying head slider 1 lifts off, such a pitch angle occurs with its leading side up that the air inflow side thereof lifts higher than the air outflow side thereof. Furthermore, the lowest fly height would occur at an area near the head 6 because the rear edge of the center pad 2d having the head 6 is located behind each of the rear edge of the side pads 2b, 2c, as shown in Fig. 1. It should be noted that, the pitch angle or the like as shown in Fig. 3 is illustrated in a exaggerated manner and the pitch angle of the flying head slider 1 of the first embodiment is approximately 120 □ radian.

[0038]

On the flying head slider 1 shown in Fig. 1, the leading pad 2a and the side pads 2b, 2c include projections on their air inflow side, with the leading step 3a and the side steps 3b, 3c, which are at a lower height, being at the front, so that dust particles can flow along contours of the leading pad 2a and the side pads 2b, 2c, thereby inhibiting the dust particles from penetrating to the positive pressure generating surface 2.

[0039]

Although the center pad 2d has a recess on the air inflow side thereof, the dust particles are not likely to enter the recess of the center part 2d because the leading pad 2a acts as a barrier against the dust particles and the center step 3d has a projection at the leading end so that the dust particles can be deflected.

[0040]

On the other hand, the recess on the air inflow side of the center pad 2d enables the freedom in design to be improved on the CFH characteristics, the skew dependence characteristics, and the linear speed dependence characteristics. As specific example, as shown in Fig. 1(b), the recess on the air inflow side of the center pad 2d is formed in substantially polygon shape, so that if points 7a through 7d can be changed to any positions, the fly height can be controlled to adjust the above-mentioned characteristics freely according to drive conditions. In addition, the shape of the center pad 2b on the air inflow side thereof can be an arc shape, instead of a polygon shape, as long as there is a recess.

[0041]

Fig. 4 is a graph showing an example of a pressure distribution on the flying head slider of the first embodiment. As shown in Fig. 1, the leading pad 2a, which is wider at the front part of the flying head slider 1 and thicker at the center part thereof, is provided while the side pads 2b, 2c are also provided behind the flying head slider 1 and on the right and left sides thereof, so that, as shown in Fig. 4, an adequately large positive pressure can be generated at the front part and the right and left parts of the flying head slider 1. As a result, the flying head slider 1 can achieve adequate pitch

stiffness and roll stiffness and even when the dust particles enter, it is not likely to change its flying position, and prevents fly height from diverging or itself from being crashed.

[0042]

Fig. 5 is each of the explanatory diagrams showing comparison example of the airflow. Fig. 5(a) shows airflow, when the flying head slider 1 includes the side steps 3b, 3c as in the first embodiment shown in Fig. 1. It can be seen that providing the side steps 3b, 3c allows to be inhibited any airflow disturbance. In comparison, Fig. 5(b) shows airflow, in the case where any side steps are not included therein, from which it can be seen that the airflow disturbance generates therein. When the airflow is thus disturbed, dust particles and lubricant can adhere at a reflux portion thereof or a stagnation thereof, and thus a design is required for ensuring an airflow that is as smooth as possible. Therefore, it is important to provide the side steps 3b and 3c.

[0043]

Fig. 6 is a plane view showing a contour of the positive pressure generating surface on the flying head slider 1 of the first embodiment and the following will next describe shapes of main members of the flying head slider 1 of the first embodiment.

[0044]

Contour parts 8a, which are indicated by solid lines, has a configuration where the step 3 does not exist between the recess 4 and the leading pad 2a, the side pads 2b, 2c, and the center pad 2d.

[0045]

The contour parts 8a would be on the air outflow side

within a range of skew angles of use and since the dust particles would easily adhere to these locations if there were obviously shallow steps, the contour parts 8a falls directly to the recess 4 without any step.

[0046]

On the other hand, contour parts 8b, which are indicated by dotted lines, would be on the air outflow side within the range of skew angles of use, but parts that are close to the side edges of the flying head slider 1 can also be on the air inflow side of the flying head slider 1. For this reason, the side steps 3b, 3c extend from the side faces of the leading pad 2a to the side edges of the flying head slider 1, as well as from the side faces of the side pads 2b, 2c, respectively, and the slider side edges, because effect for inhibiting the dust particles from entering at the air inflow side is more effective as compared with addressing the issue of dust particle adhesion on the air outflow side. Furthermore, if the side faces of the leading pad 2a and the side pads 2b, 2c were to extend out to the side edges of the flying head slider 1, chipping of the edge parts would be unavoidable during manufacturing, so that it is advantageous to extend the side steps 3b, 3c from the slider side edges to the side face of the leading pad 2a and to the side faces of the side pads 2b, 2c, respectively also from the manufacturing standpoint.

[0047]

Furthermore, the steps are allowed at the parts of connection between the leading pad 2a and each of the side steps 3b, 3c because an advantage of being able to inhibit the airflow disturbance is more significant than a disadvantage of particle adhesion. However, in order to

inhibit dust particles from adhering, the side steps 3b, 3c have configurations such that they are narrower toward the leading end thereof and lengths of the connection parts between the leading pad 2a and each of the side steps 3b, 3c are minimized.

[0048]

On the flying head slider 1, the contour lines of the positive pressure generating surface 2 and the step 3 preferably have configurations such that they are consist of only curved lines or of combinations of curved lines and tangent of the curbed lines, without any discontinuity. However, as an exception, the contour lines would be discontinuous at interfaces 9a between areas where there is no step 3 between the positive pressure generating surface 2 and the recess 4 and areas where there is the step 3 between the positive pressure generating surface 2 and the recess 4, as well as at cross points 9b between the contour lines of the positive pressure generating surfaces 2 that are connected to the slider edge faces, and the slider edge surfaces.

[0049]

These exceptions are due to two masks that are used for a step for forming the step 3 and for a step for forming the positive pressure generating surface 2. In other words, Fig. 7 is a plane view that shows an example of a configuration of the masks, in which solid lines show a contour of a mask 10a for forming the step 3, while dotted lines show a contour of a mask for forming the positive pressure generating surfaces 2.

[0050]

In a manufacturing process for the flying head slider

1, firstly the mask 10a is used for covering an area where the step 3 shown in Fig. 1 is to be formed, with a resist, while an area of the recess 4 is etched away. Next, the mask 10b is used for covering areas where the positive pressure generating surface 2 is to be formed, with a resist, and the areas for the step 3 and the recess 4 are etched away.

[0051]

In the mask 10b, a part corresponding to the rear edge contour of the leading pad 2a and parts corresponding with inner side contours of the side pads 2b, 2c, namely, parts that face the recess 4, respectively, are enlarged in size with respect to the mask 10a.

[0052]

This allows cross points 11 where patterns on the mask 10a and the mask 10b would cross each other to be created, and as a result thereof, discontinuities in the contours of the positive pressure generating surfaces 2 would also be created, but shaping the parts of the positive pressure generating surfaces 2 as such is advantageous from the manufacturing stand point because adverse effects for entirely shape would be avoided, even if there were a slight misalignment between the masks.

[0053]

Fig. 8 is a plane view showing an example of a configuration of a flying head slider of a second embodiment. A flying head slider 12 of the second embodiment includes two separate leading pads 2La, 2Ra with respect to a center line in a longitudinal direction of the slider.

[0054]

Providing the two separate leading pads 2La, 2Ra allows to be improved the roll stiffness and further to be enhanced

the slider fly height stability. Furthermore, side pads 2b, 2c have recesses on the air inflow side thereof. When the side pads 2b, 2c have the recesses on the air inflow side, it is possible to control the fly height by changing the shapes of these recesses and thus achieve greater design flexibility.

[0055]

It is to be noted that whether or not to include a center groove, which constitutes a main difference between the flying head slider 1 of the first embodiment and the flying head slider 12 of the second embodiment, and shapes of the projections and the recesses on the side pads changes their optimal values according to an amount of dust particles that might enter, so that their shapes must be optimized experimentally according to foreseeable conditions in the drive to be used.

[0056]

Fig. 9 is a plane view showing an example of a configuration of a hard disk drive of a second embodiment and then, the following will describe an example of a variation of the hard disk drive. In Fig. 9, a cover, which is not shown in the figure, has been removed in order to describe an internal configuration of a hard disk drive 31.

[0057]

The hard disk drive 31 of the second embodiment is called as a removable typed one in which a disk cartridge 33 storing a disk 32 is attached to the hard disk drive 31 in a removable manner.

[0058]

The disk cartridge 33 is in a shape of a thin box and has an opening 34 on one side face thereof. A shutter 35,

which can be opened and closed, is placed on the opening 34. The shutter 35 closes the opening 34 when the disk cartridge 33 is removed from the hard disk drive 31, in order to protect the disk 32 inside the disk cartridge 33.

[0059]

Although not shown in the figure, the hard disk drive 31 includes, for example, a mechanism for attaching the disk cartridge 33 in a removable manner and a spindle motor for rotating the disk 32 inside the disk cartridge 33.

[0060]

A head actuator 25 is fitted so that an arm main body 24 can rotate around a pivot 26 as an axis. Furthermore, the head actuator 25 is rotationally driven by a voice coil motor 28, which is placed on an opposite side from a suspension 23 across the pivot 26.

[0061]

The suspension 23 extends toward the disk 32 and is attached at a prescribed angle with respect to the direction in which the arm main body 24 extends, and the head actuator 25 has a bent shape like chevron viewed from above. The suspension 23 of the head actuator 25 enters through the opening 34 of the disk cartridge 33.

[0062]

In the removable hard disk drive 31, the disk cartridge 33 is removable so that dust particles can have a significant effect even when a barrier structure against the dust particles such as the shutter 35 is used. For this reason, the effects of dust particles can be mitigated by utilizing the flying head slider 1 of the first embodiment or the flying head slider 12 of the second embodiment.

[0063]

It should be noted that, although the embodiments described above have been preferred examples of the present invention and have included various limitations that are preferred from a technological standpoint, the scope of the present invention is not limited to these embodiments unless specific limitations to the invention are described in the above description.

[0064]

[Effects of the Invention]

As described above, according to the invention, the U-shaped leading pad having a projection on an air inflow side thereof is positioned at a front part of the slider as positive pressure generating surface, so that this leading pad can ensure stiffness mainly in pitch direction. Further, two side pads are positioned behind the leading pad and on the right and left sides thereof, so that these side pads can ensure stiffness mainly in roll direction.

[0065]

Further, the center pad having a recess on the air inflow side thereof is positioned between the two side pads and behind the leading pad, so that shapes of the center pad enables fly height characteristics to be controlled, thereby ensuring freedom in design.

[0066]

The step having a lower height than the positive pressure generating surface extends to a front edge and side edges of the slider at a part to become the air inflow side thereof in each positive pressure generating surface, thereby preventing dust particles from entering into a boundary surface between the flying head slider and the disk.

[0067]

Thus, it has an advantage such that the disk storage apparatus having an extremely low-flying system or a flying system under a dusty circumference can be not susceptible to the effects of dust particles.

[0068]

Further, it also has an advantage such that CFH characteristics, skew dependence characteristics, and linear speed dependence characteristics can be improved and excellent fly height characteristics can be also achieved with ensuring the protection against dust particles.

[Brief Description of the Drawings]

[Fig. 1] are the explanatory diagrams each showing an example of a configuration of a flying head slider of a first embodiment.

[Fig. 2] is a perspective diagram showing an example of a configuration of a hard disk drive of the first embodiment.

[Fig. 3] is an explanatory diagram showing an example of an operation of the flying head slider.

[Fig. 4] is a graph showing an example of pressure distribution on the flying head slider of the first embodiment.

[Fig. 5] are the explanatory diagrams each showing comparison examples of airflow.

[Fig. 6] is a plane diagram showing conditions at contours of the positive pressure generating surface of the flying head slider of the first embodiment.

[Fig. 7] is a plane diagram showing an example of a configuration of a mask.

[Fig. 8] is a plane diagram showing an example of a

configuration of a flying head slider of a second embodiment.

[Fig. 9] is a plane diagram showing an example of a configuration of a hard disk drive of the second embodiment.

[Fig. 10] are the plane diagrams each showing an example of a configuration of a flying head slider of a prior art.

[Fig. 11] is a plane diagram showing an example of a configuration of a hard disk drive of the prior art.

[Description of Reference Numbers]

1...flying head slider; 2... positive pressure generating surface; 2a...leading pad; 2b, 2c...side pad; 2d...center pad; 3...step; 3a...leading step; 3b, 3c...side step; 3d...center step; 4...recess; 5...negative pressure generating area; 6...head; 12... flying head slider; 21...hard disk drive; 22...disk; 23...suspension; 24...arm main body; 25...head actuator; 26...pivot; 27...casing; 28...voice coil motor

[Name of the Document] Abstract

[Abstract]

[Problem]

To keep out dust particles while improving the CFH characteristics, skew dependence characteristics, and linear speed dependence characteristics for enhancing fly height characteristics.

[Means for solving Problem]

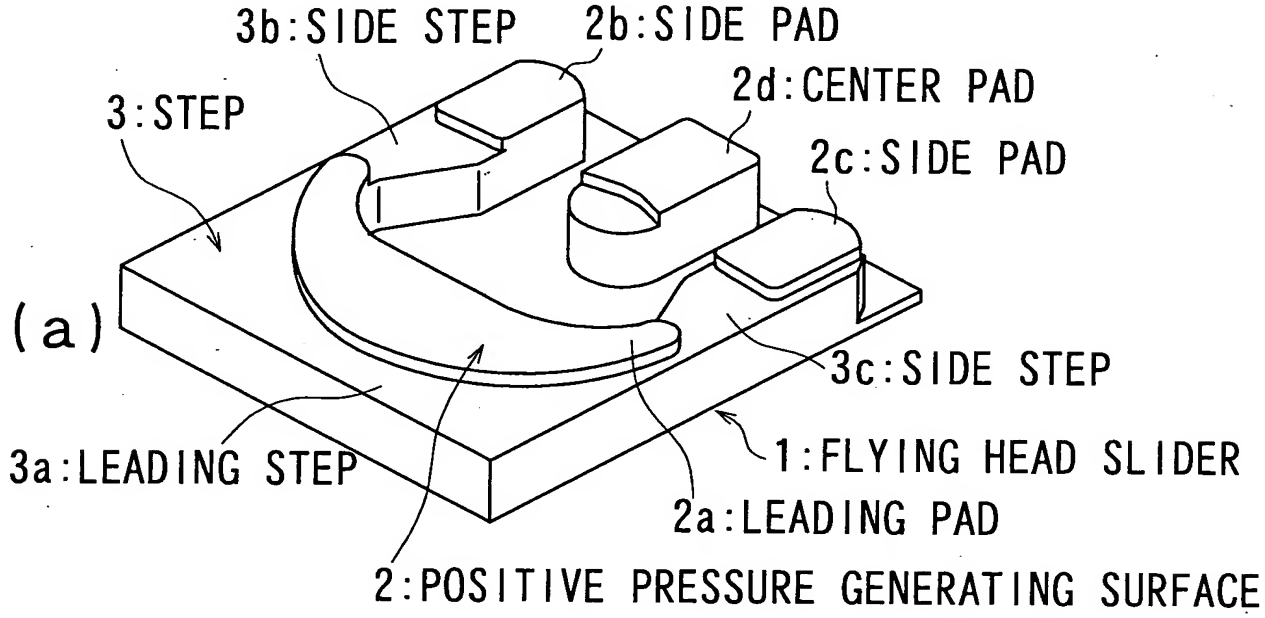
A flying head slider 1 has a positive pressure generating surface 2, which includes a leading pad 2a for ensuring stiffness in pitch direction; 2 pairs of side pads 2b, 2c, which are positioned behind of the leading pad 2a and on the right and left sides thereof, for ensuring stiffness in roll direction; and a center pad 2d, which is positioned between the side pads 2b, 2c, for controlling the fly height characteristics. Furthermore, at a part to became air inflow side in the flying head slider 1, a step 3 that is at a lower height than the positive pressure generating surface 2 extends to a front edge and side edges of the slider, thereby preventing dust particles from entering a boundary surface between the flying head slider and a disk to achieve the stable fly height characteristics.

[Selected Drawing] Fig. 1

【DOCUMENT NAME】 DRAWINGS

FIG. 1

CONFIGURATION EXAMPLE OF FLYING HEAD SLIDER OF FIRST EMBODIMENT



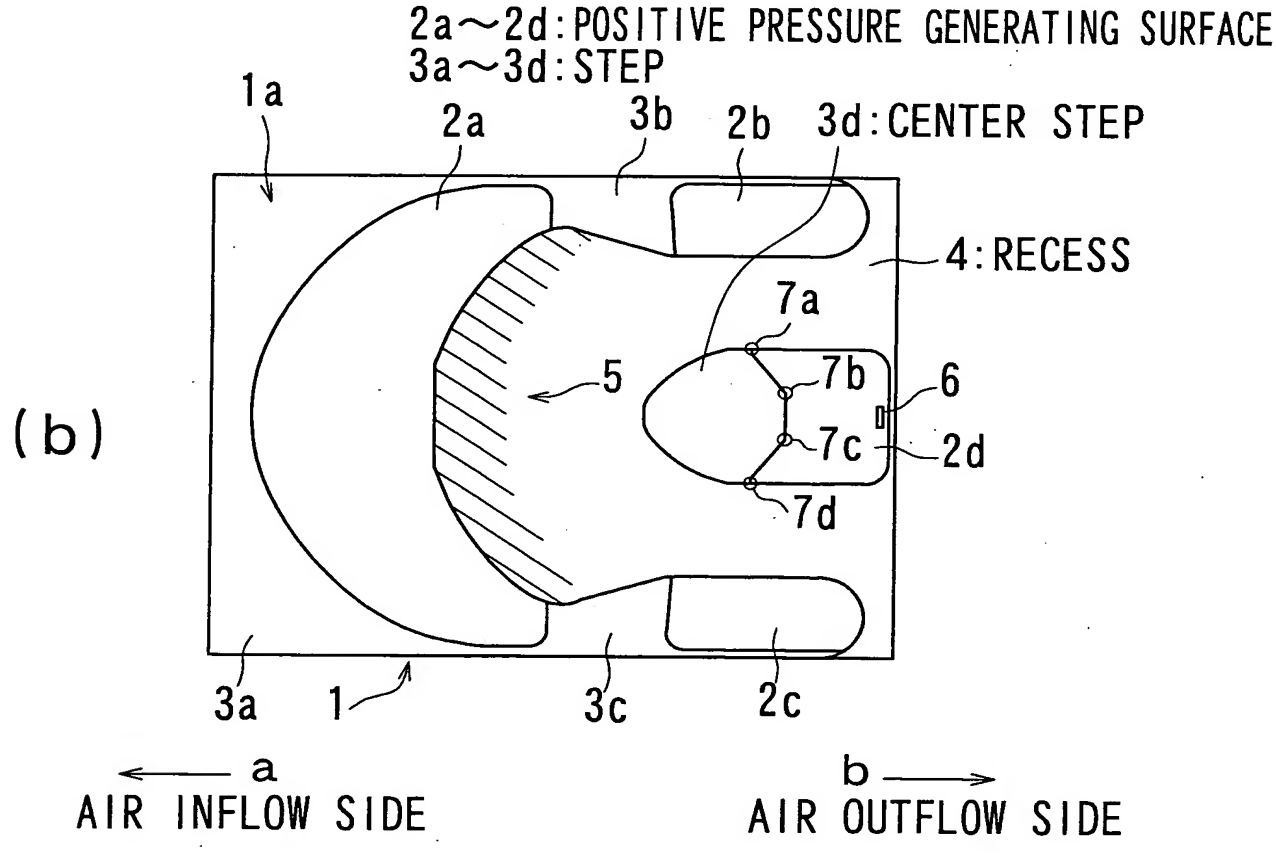


FIG. 2

CONFIGURATION EXAMPLE OF HARD DISK DRIVE OF FIRST EMBODIMENT

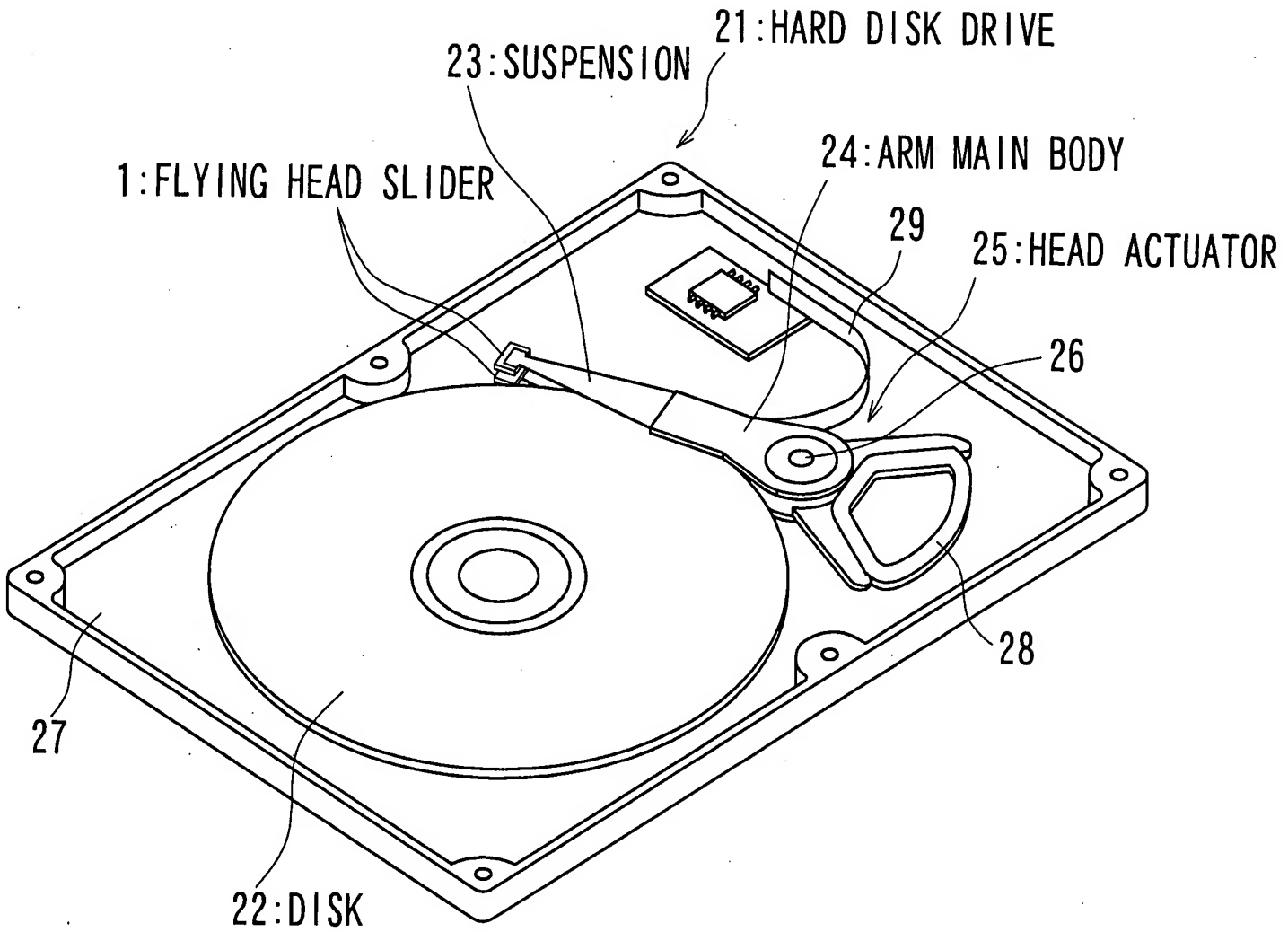


FIG. 3

OPERATION EXAMPLE OF FLYING HEAD SLIDER

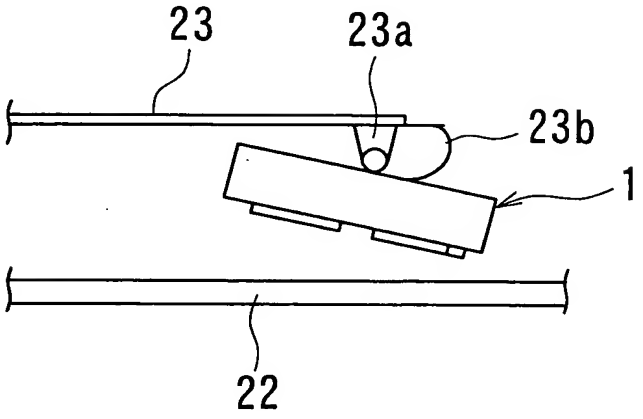


FIG. 4

AN EXAMPLE OF PRESSURE DISTRIBUTION
IN FIRST EMBODIMENT

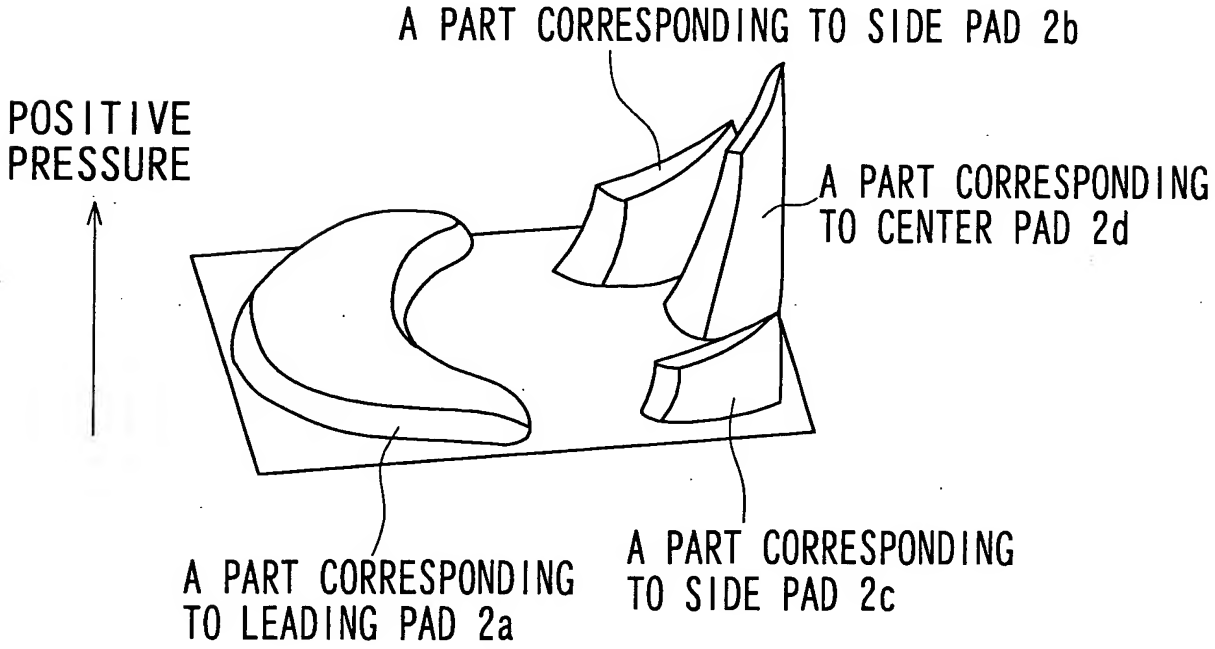
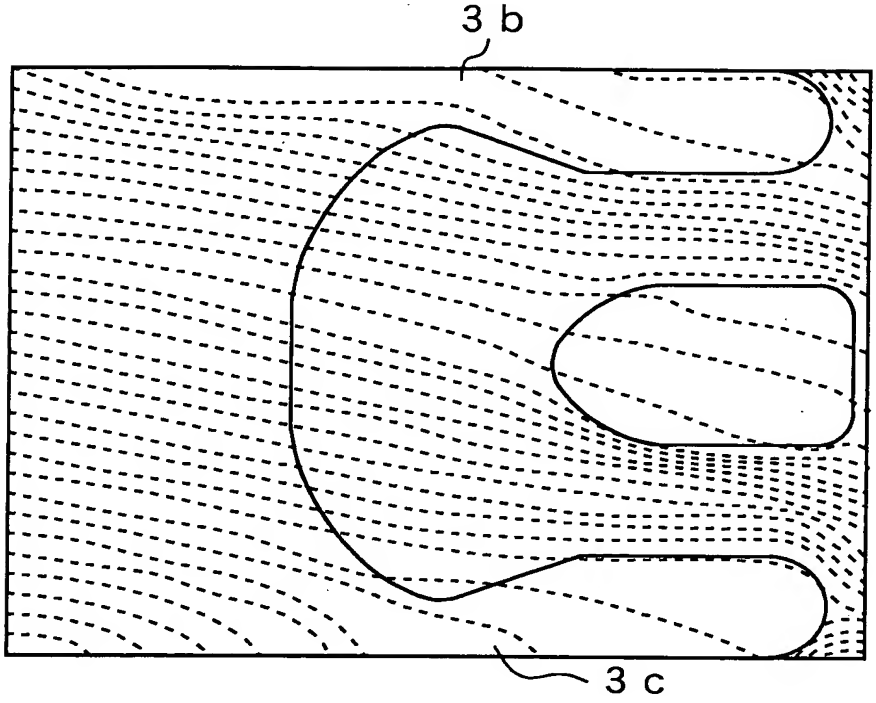
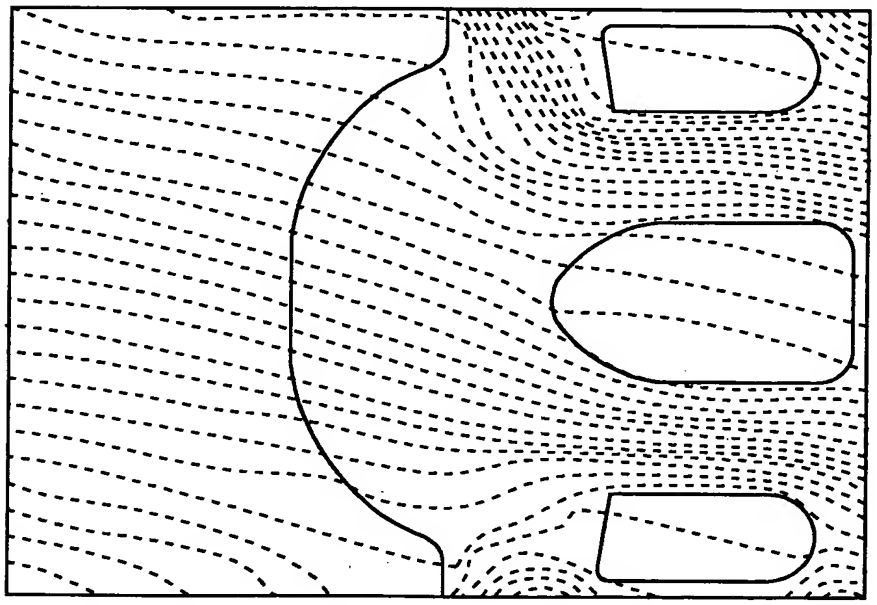


FIG. 5

COMPARISON EXAMPLE OF AIRFLOW



(a) WITH SIDE STEPS



(b) WITHOUT SIDE STEP

FIG. 6

SITUATION CONTOUR OF POSITIVE PRESSURE GENERATION SURFACE

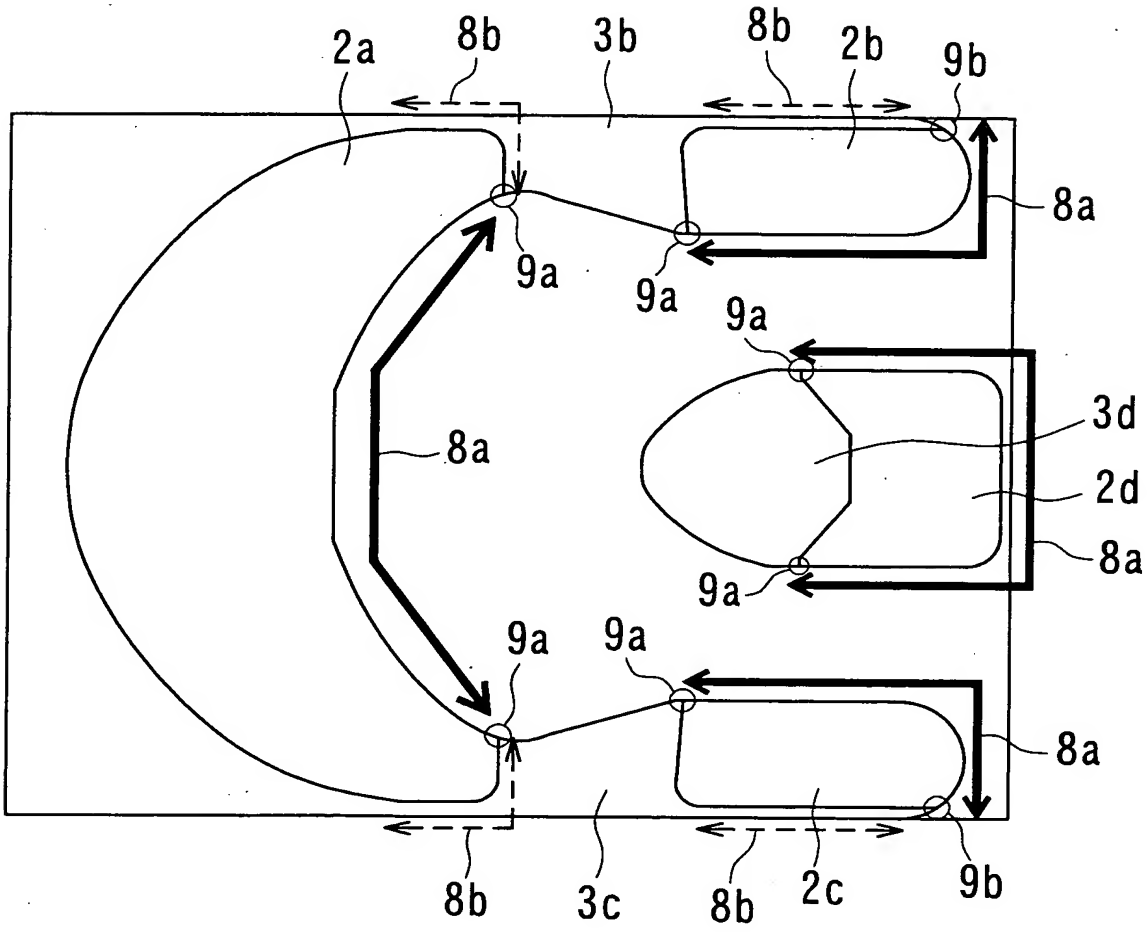


FIG. 7

CONFIGURATION EXAMPLE OF MASK

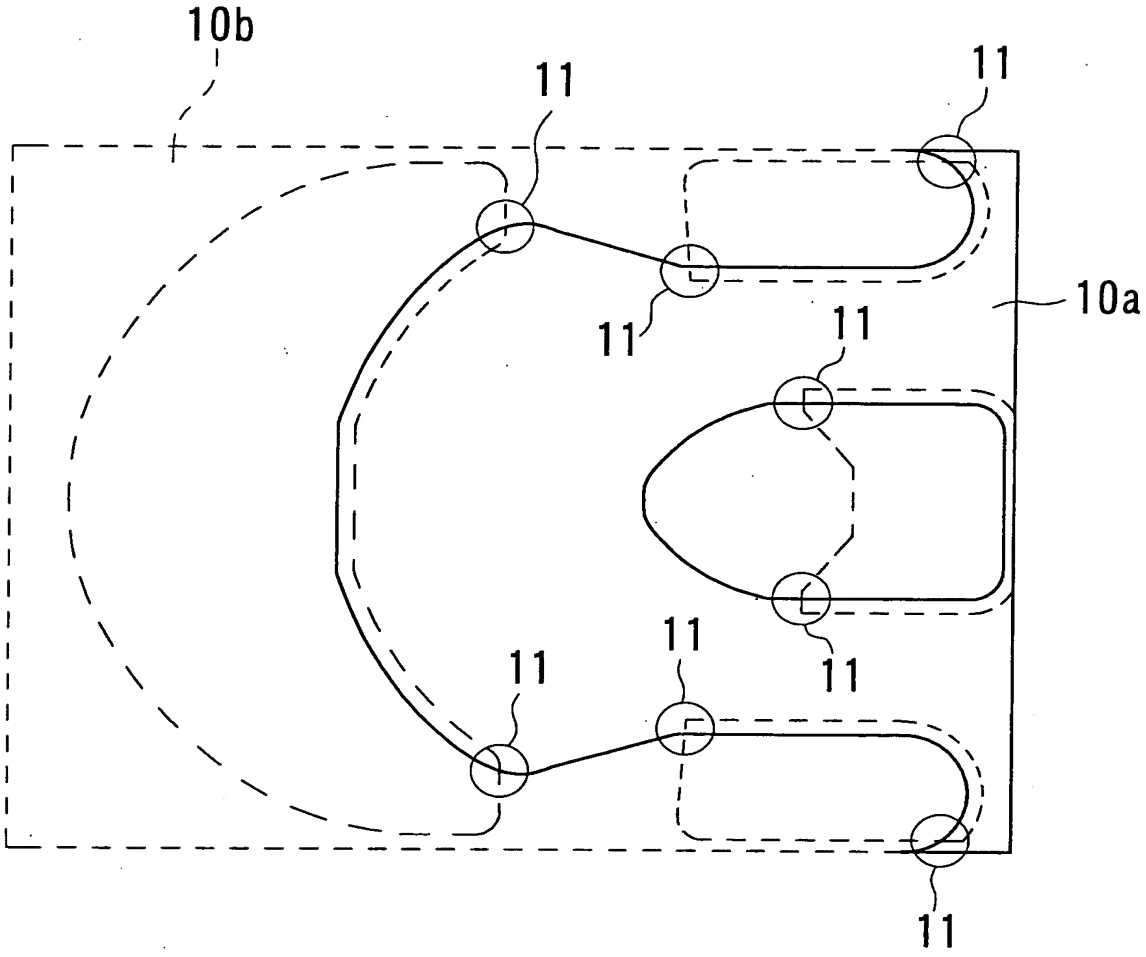


FIG. 8

CONFIGURATION EXAMPLE OF FLYING HEAD SLIDER OF SECOND EMBODIMENT

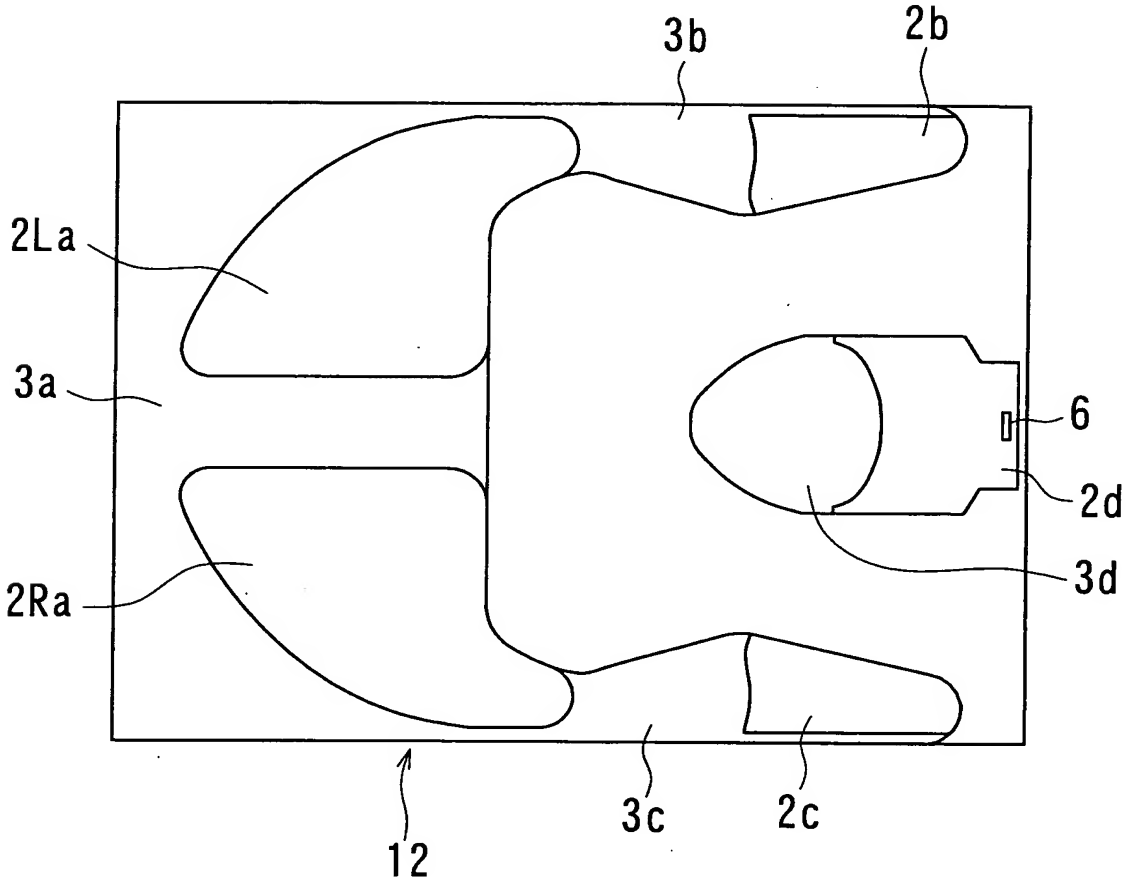


FIG. 9

CONFIGURATION EXAMPLE OF FLYING HARD DISK DRIVE OF SECOND EMBODIMENT

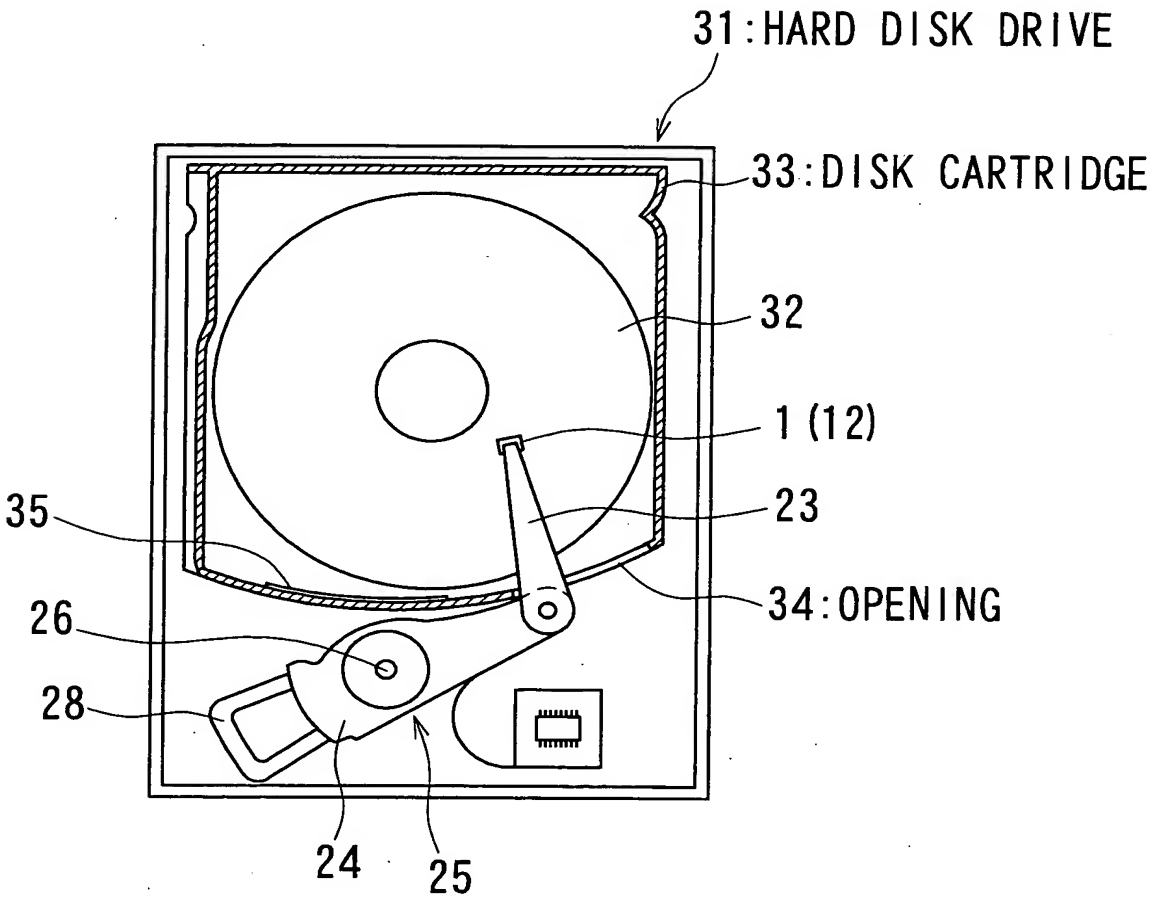
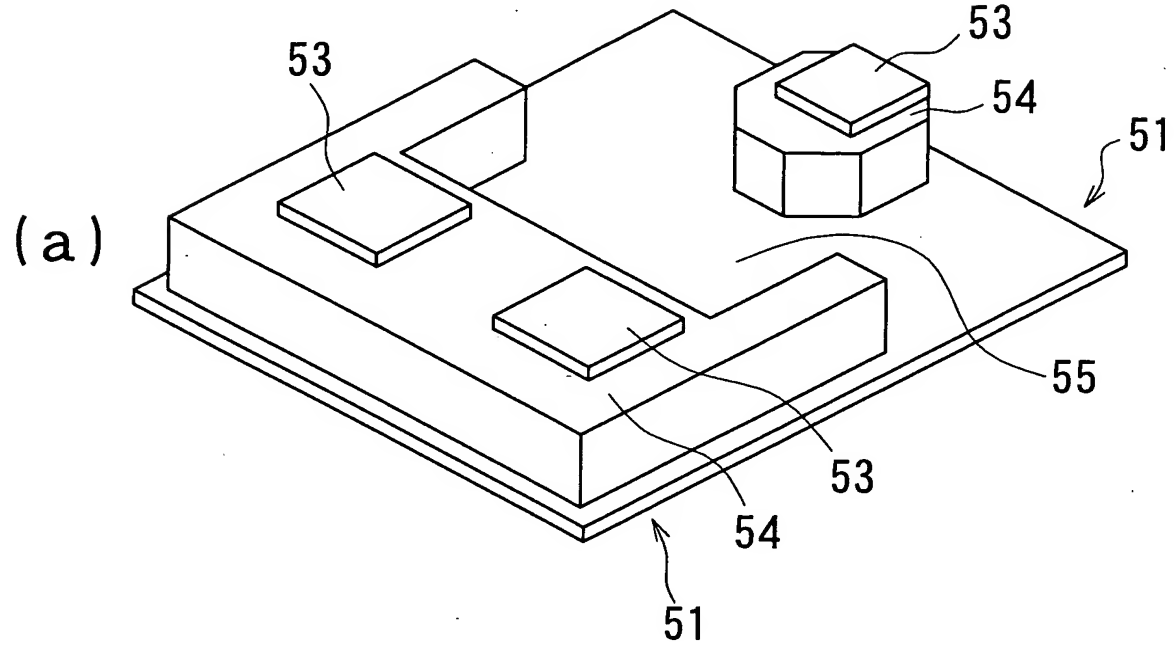


FIG. 10

CONFIGURATION EXAMPLE OF FLYING HEAD SLIDER OF PRIOR ART



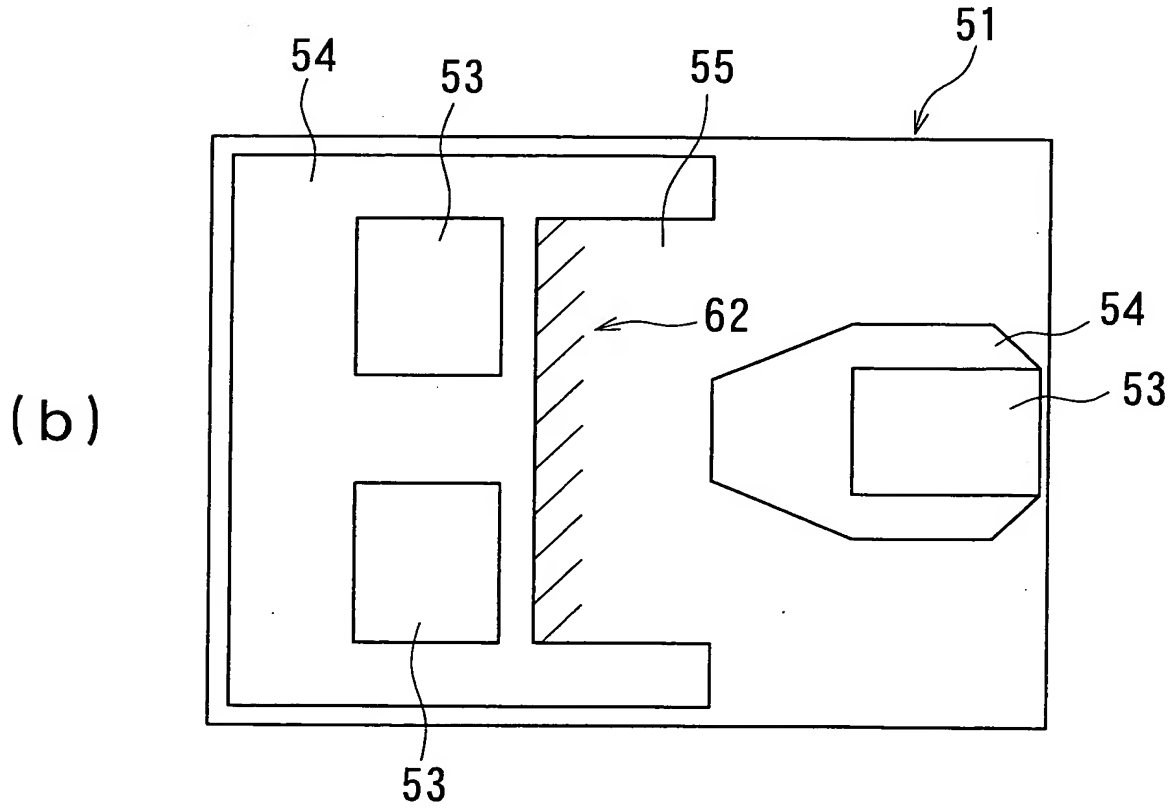


FIG. 11

CONFIGURATION EXAMPLE OF HARD DISK DRIVE OF PRIOR ART